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CONE PRODUCTION, SEED YIELD AND SEED VIABILITY AMONG CLONES IN A SCOTCH PINE SEED ORCHARD

James R. Brandle

FINAL PROJECT REPORT

COOPERATIVE AGREEMENT NO. 28-C3-289

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1. Title

Cone Production, Seed Yield and Seed Viability Among Clones in a Scotch Pine Seed Orchard.

2. Principal Investigators

James R. Brandle, Associate Professor
William R. Lovett, Associate Forester
Teresa K. Boes, Research Assistant

Department of Forestry, Fisheries and Wildlife, University of Nebraska, Lincoln, NE 68583-0814.

3. General Remarks

The characterization of variability among the forty-two clones in the seed orchard was completed as outlined in the objectives of the project study plan. The sampling schedule was altered slightly because of the incomplete sampling of the 1984 phenological data, and because a doctoral graduate research assistant was hired for the project rather than a masters research assistant. The 1985 progress report requested an extension of the final report due-date from June 30,1986 to August 30, 1986 so that the 1986 phenological data could be collected, analyzed and included in this report. In place of the thesis called for in the sampling schedule, a doctoral dissertation will be prepared that will incorporate data from

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this study. Journal publications will also be written to disseminate the information resulting from this project.

The time required to collect every cone from each tree limited the sampling of cone and seed data. In 1983, four blocks were used for data collection as described in the 1983 progress report. In 1984 and 1985, data were collected from all trees in five blocks. The blocks used for collecting cone and seed yield data were identified as numbers 3, 6, 9, 12 and 15 in the seed orchard (Figure 1).

During the summers of 1985 and 1986, the entire seed orchard was aerially sprayed with the insecticide Ambush^{R} in an attempt to control populations of western conifer seed bug (Leptoglossus occidentalis Heidemann). The presence of large numbers of seed bugs had been noted during data collection in 1983 and 1984, but hardly any were noticed in 1985. No attempt was made to quantify the effect of the insecticide application on cone and seed yields.

4. Results of Study

Objective 1: To determine the amount of viable seed produced on a per cone basis for each of the forty-two clones.

Yield variables estimated for each source in this study included: number of cones per square meter of canopy surface area, total number of cones per tree, weight of seed per cone, total weight of seed per tree, number of seed per cone and total number of seed per tree. Cone and seed collection procedures were as described in the project study plan and progress reports.

All variables involving seed weight or number of seed are based on the amounts of petroleum ether-cleaned seed for each source.

To calculate surface area, a computer program was written which used tree height and crown diameter measurements, and was based on three-dimensional images of the symmetrical plane shapes described by the Systematics Association Committee for descriptive Biological Terminology (Taxon 11: 145-156). Ranking the sources by the number of cones produced per square meter of surface area (Table 1) can be useful for identifying sources that may be compact but very productive as opposed to sources that are larger but have about the same total cone production. However, for the years that data were collected during this study, the ranking of sources from high producers to low producers did not change much when the total number of cones produced (Table 2) was compared to the number of cones produced per square meter of surface area (Table 1).

Pine seed is commonly sold by weight, so the yields from the sources in the seed orchard were also compared in this manner. After seed subsamples from each tree were cleaned, they were weighed, and yields were calculated as milligrams of seed per cone for each source (Table 3). An estimate of the amount of seed by weight produced by each tree was obtained using the values for total cone production per tree (Table 4).

The seed weight per cone values (Table 3) tend to reflect the size of seed produced by each source. Sources that produce larger seeds will be ranked higher, but this is not necessarily a good measure of total yield. When large seeds are formed,

usually less are produced than when smaller seeds are formed, and sources that produce large seeds tend to have fewer cones than sources producing smaller seeds.

The seed weight per tree values (Table 4) take into consideration the amount of cone production by each source. Therefore, sources that produce a small number of large seeds in relatively few cones will usually be ranked lower than sources that produce smaller seeds but many cones. A comparison of Table 3 with Table 4 will quickly show that many of the sources ranked high for seed weight per cone are not found among the sources with the greatest seed weight per tree. As a measure of total yield, seed weight per tree is probably a more accurate reflection of each source's worth than seed weight per cone.

Pine seed sources can also be compared by weight per 1000 seeds (Table 5). This measure is a more direct indicator of seed size, and like the seed weight per cone values, is of little use in determining actual yield.

Another method of describing yield from the seed orchard is by the actual number of seed produced by each source. Table 6 indicates the number of seed produced per cone, while Table 7 ranks the sources by the number of seed produced per tree. Ranking sources by the number of seed produced per cone can be useful in determining which trees in the orchard should have priority during harvest. Concentrating harvest efforts on the sources ranking highest in seed yield per cone will help to maximize seed yield with a minimum of labor.

Many of the sources with a high number of seed per cone also have a high number of seed per tree. However, some sources

may have a high number of seed per cone and a low number of seed per tree if they do not produce many cones. For example, source YU 242 F-4 has a rank of 3 in number of seed per cone (Table 6), but is ranked 32 in number of seed per tree (Table 7). In Table 2, YU 242 F-4 is ranked 41, which makes it one of the worst cone producing sources, and therefore not a good source to consider for an efficient seed harvest. On the other hand, source GE 203 K-2 is ranked 20 in number of cones produced per tree (Table 2), but is ranked 4 in number of seed per cone (Table 6) and 3 in number of seed per tree (Table 7).

Another factor to be considered when discussing seed orchard yield is the germination percentage of each source (Table 8). These values were calculated by comparing the weight of the dewinged seed for each tree to the weight of the same seed lot after dead and broken seed had been removed in petroleum ether. Although germination is not a quanity that measures total yield from the seed orchard, these vaules will have a bearing on how much of the yield from each source is actually usable. However, because the percentages are based on seed weight instead of seed number, caution is advised in interpreting the rank of sources by germination percentages.

Large seed lots are likely to have a greater number of dead seed than small seed lots. The precision of the measurements used to determine the weight of the seed lots before and after petroleum-ether cleaning was less than what is necessary to detect the removal of a few dead seed. Therefore, when dead seed were removed from seed lots with a small number of seed, the

weight changed less than in seed lots with a large number of seed. Source GR 551 M-2 appears to have 100% germination (Table 8), but since very few seeds were produced at all by this source (Table 4), the seed lot weight probably didn't change much when dead seeds were removed. This example as well as the previous ones, illustrate that it may be beneficial to evaluate each source according to its average rank for all of the yield variables (Table 9). However, as discussed earlier, all yield variables may not be equally important in evaluating seed orchard preformance for specific needs, so average rankings may change if certain variables are considered to be more important than others.

Although yield variables require major consideration when evaluating the sources from the seed orchard, other factors need attention as well. The seed orchard was developed to improve Scotch pine planting stock for the Nebraska Christmas tree industry. Therefore, not only is it important to determine which trees are high-yielding, but trees that have desirable shape, color, growth rate and needle retention need to be identified as well. The extent of this study did not cover evaluation of the sources as Christmas trees, but the aesthetic value of one source was noticed because it was one of the worst yielding sources. Source GR 551 M-2 was ranked 40 out of 42 when all of the yield variables were considered (Table 9), but the color and fullness of this source appeared to be very desirable Christmas tree characteristics.

Objective 2: To determine the time of staminate cone dehiscience by clone.

In late April, the development of the staminate cones was monitored to determine when dehiscience began. When the first pollen release was detected, the condition of the staminate cones on each tree in every block was observed every second day until dehiscience ended. The average beginning dates of dehiscience ranged from April 29 to May 10, and the average ending dates ranged from May 12 to May 20 (Figure 2).

As described in the 1984 progress report, complete information on staminate cone dehiscience was not collected for 1984. However, observations made at that time indicated that the average beginning date of dehiscience was much later in 1984 (May 17) than in 1985 and 1986 (May 3). A possible explaination for the delay in dehiscience in 1984 is that the cool and wet weather conditions of that spring were unfavorable for cone development. The impact of delayed cone development on seed yield has not been determined.

The length of time dehiscience occurred for any one source ranged from 7 to 13 days (Table 10). This variable is as important as the actual dates of dehiscience, because a source that has pollen avaliable for a relatively long period of time is likely to pollinate more ovulate cones than a source that has pollen avaliable for only a short time. In general, sources with early staminate cone dehiscience appeared to have pollen avaliable for a longer time than sources with late staminate cone dehiscience.

Another factor to consider when discussing staminate cone

dehiscience is the amount of pollen available from each source. Although the actual number of staminate cones per tree were not counted, each tree was rated on a scale of 1 to 5, with 1 being no staminate cones visible and 5 being an excessive number of staminate cones visible (Table 11). Sources with late staminate cone dehiscience appeared to have lower relative pollen production than sources with earlier dehiscience. However, the few cases where this was not true were very noticable. Sources YU 242 F-4 and GR 243 G-4 began dehiscience early (April 30), but both are ranked 27 in relative pollen production, while source FR 239 K-1 begins dehiscience about a week later (May 7), but is ranked 12 in relative pollen production. This information indicates that when sources are being evaluated based on staminate cone performance, all of the variables should be considered rather than making generalizations from a few pieces of data.

Objective 3: To determine pollen viability by clone.

Staminate cones from each source were collected during the time of dehiscience (May 10 and 11, 1986). The cones were air dried in paper bags (25°C), and the pollen that was released was collected and stored at 4°C. Not more than two weeks after collection, the pollen was tested for viability by placing a small amount from each source in distilled water for 48 hr. A hemacytometer was used to count total pollen grains and the number of germinated pollen grains in a drop of the pollen-water mixture. Pollen was counted as germinated only if the pollen

tube was at least as long as the diameter of the pollen grain. The percent of viable pollen avaliable from each of the sources (Table 12) is important to consider when determining what crosses are possible.

Some of the sources that began dehiscience early appeared to have poorer pollen viability than sources with later dehiscience. For example, source GR 243 G-4 began dehiscience on April 30 but had only 5% viable pollen, while source SP 245 J-1, which began dehiscience a week later, had 91% viable pollen. The time of staminate cone collection was chosen in an attempt to sample each source while dehiscience was occuring. Possibly, the most viable pollen is released at the beginning of dehiscience, and viability decreases as dehiscience continues. If this is true, the beginning dates of staminate cone dehiscience are much more important in determining pollen avaliability than the ending dates or the number of days of dehiscience. Further work needs to be done to determine the relationship between the time of staminate cone sampling and the amount of viable pollen produced by a source.

Objective 4: To determine the time of ovulate cone receptivity by clone.

The average beginning dates of ovulate cone receptivity ranged from May 1 to May 10, and the average ending dates ranged from May 6 to May 19 (Figure 3). Ovulate cones for any one source usually became receptive after the beginning of staminate cone dehiscience, and receptivity ended before dehiscience ended. Therefore, the condition of the ovulate cones on each tree in

every block was monitored every second day along with the condition of the staminate cones.

In 1984, data were collected on the dates of ovulate cone receptivity, and this information is presented in the 1984 progress report. As with the data on staminate cone dehiscience, the average beginning date of ovulate cone receptivity was much later in 1984 (May 21) than in 1985 and 1986 (May 4). Again, this delay was probably due to unfavorable weather conditions.

Although a complete set of data was collected on ovulate cone receptivity in 1984, it was not analyzed with the 1985 and 1986 data. The 1984 data was so different that it would obviously bias the results if it were included with the other years of data. A biased data set may cause comparisons between the dates of staminate cone dehiscience and the dates of ovulate cone receptivity to be misleading. Although the dates of staminate cone dehiscience and ovulate cone receptivity were later in 1984 than in 1985 and 1986, the length of time of receptivity for each source was still about the same as the 1984-1985 average. Also, the ranks of sources from those with earliest ovulate cone receptivity to those with latest ovulate cone receptivity in 1984 were similar to the average ranks from the 1985 and 1986 observations

The length of time of receptivity for any one source ranged from 4 to 10 days (Table 13). Due to the highly variable weather conditions in the spring, sources with longer periods of ovulate cone receptivity are probably more likely to be cross-pollinated than sources with short periods of receptivity. Sources with long periods of staminate cone dehiscience did not necessarily

have long periods of ovulate cone receptivity. For all sources, the number of days of ovulate cone receptivity were less than the number of days of staminate cone dehiscience, and the days of receptivity were usually within the days of dehiscience for any one source. In only one case (BE 318 D-3) did a source have cones receptive after dehiscience for that source had ended, and in two cases (SP 218 L-3 and SP 245 J-4) ovulate cones were receptive before dehiscience from these sources began.

Objective 5: To determine which crosses are possible.

For most sources, the beginning and ending dates of staminate cone dehiscience overlap the beginning and ending dates of ovulate cone receptivity, so most crosses are possible. One notable exception to this generalization is source SP 245 K-2. The average beginning date of staminate cone dehiscience for this source is May 10, which is the same day as the average ending date of ovulate cone receptivity for all sources combined. Twenty-seven of the 42 sources had ovulate cone receptivity ending dates before pollen was avaliable from source SP 245 K-2, so these crosses would not be likely. On the other hand, ovulate cone receptivity for source SP 245 K-2 also began on May 10, which means that pollen from all 41 other sources was still avaliable for at least two days.

Other crosses that would not be likely are between sources that have ovulate cone receptivity ending dates before the beginning date of staminate cone dehiscience for another source. The average ending date of ovulate cone receptivity for sources

GR 243 I-1, IT 556 G-1 and TU 220 M-4 was May 6, so these sources probably would not be pollinated by sources with average beginning dates of staminate cone dehiscience on or after May 6 (FR 240 N-4, SP 218 L-3, SP 245 J-1, SP 245 N-3, SP 245 F-1, FR 240 A-4, SP 245 K-2). Likewise, sources with an average ovulate cone receptivity ending date of May 8 (GE 203 I-2, GE 203 K-2, GR 243 G-4, GR 551 H-3, GR 551 M-2, IT 557 G-1, YU 242 F-4, YU 242 G-1) probably would not be pollinated by sources with average staminate cone dehiscience beginning dates on or after May 8 (FR 240 A-4, SP 245 F-1, SP 245 K-2).

The overlap of dates of dehiscience with dates of receptivity determine which crosses are possible, but the probability of all crosses depends on several factors. The amounts of pollen avaliable (Table 11) and the viability of pollen from each source (Table 12) are two important variables to consider when determining which sources can be crossed with which others. Also, wind speed and direction at the time of dehiscience will influence what crosses are made, but even with favorable wind speeds, most of the pollen from any one tree will only travel to the nearest downwind neighbors. Therefore, the design of the seed orchard and what sources are actually placed next to each other will also influence the probability of crosses. The large number of combinations of variables involved when evaluating 42 sources for which crosses are probable make it desirable to choose only a few sources of interest before this type of evaluation is attempted. The fact that most sources have compatible periods of dehiscience and receptivity, and that the sources are randomly arranged within each block of the orchard,

should mean that phenology is not likely to influence yield variables to any great extent.

5. Summary of Results

Yield from the seed orchard was measured for each source by the number of cones per square meter of canopy surface area, the number of cones per tree, the seed weight per cone, the seed weight per tree, the weight per 1000 seeds, the number of seed per cone, the number of seed per tree, and the percent germination. Each source was ranked from best to worst for each variable, then for all variables combined. Depending on the purpose of the yield evaluation, some variables may be more useful than others. Yield variables do not take aesthetic characteristics into consideration, and these characteristics were not evaluated in this study. However, since the orchard was established to improve Christmas tree planting stock, aesthetic values should not be forgotten.

The major purpose of the phenology evaluation was to determine if the time of ovulate cone receptivity for most sources was greatly different from the time of staminate cone dehiscience. If they were very different, the ovulate cones would not be pollinated very well, which would be a cause of low seed yields. However, the results of this study indicated that most sources do have compatible dehiscience and receptivity times, so incompatible flowering phenology is probably not a cause of low seed yield. A few sources had ended ovulate cone receptivity by the time other sources were beginning staminate

cone dehiscience, but even the latest flowering source had other sources either receptive or dehiscient at the same time.

Based on the average values of data collected in this study, a hypothetical "average" source from this seed orchard would have the following characteristics:

7.02 cones per square meter of canopy surface area
409.66 cones per tree
92.51 mg seed per cone
32.71 g seed per tree
10.86 g per 1000 seed
11.21 seed per cone
4202.87 cleaned seed per tree
87.69 % bulk seed germination
May 3 as the beginning date of staminate cone dehiscience
May 14 as the ending date of staminate cone dehiscience
10.94 days of staminate cone dehiscience
54.00 % pollen germination
May 4 as the beginning date of ovulate cone receptivity
May 10 as the ending date of ovulate cone receptivity
6.80 days of ovulate cone receptivity.

Scotch pine has a potential yield of 45-55 seeds per cone since it has 25 ovuliferous scales, each capable of bearing two mature seeds[1]. Studies from Scotland[1] and southern Sweden[2] indicate average seed yields of 10 seed per cone and 15-20 seed per cone respectively. The average for the orchard at Mead was 11 seed per cone, which is below or near the low end of the other seed orchard averages.

A comparison of total orchard yield at Mead (6 lb seed per acre) with yields reported in Seeds of Woody Plants in the United

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[1] Brown, I.R. 1970. Seed production in Scots pine. pp. 55-63. IN: L.C. Luckwill and C.V. Cutting (eds.). Physiology of Tree Crops. Adademic Press, New York.

[2] Johnsson, H., C.L. Kiellander and E. Stefansson. 1953. Cone development and seed quality on pine grafts. Sv. Skogsv. Foren Tidsker. 51: 358-389.

States (10-20 lb seed per acre)[3] also indicated below average production from the Mead orchard. Total seed yields are difficult to compare since previous reports do not indicate values for cones per tree or trees per acre. However, it does appear that total seed production from the orchard at Mead is well below its potential.

6. Areas For Future Study

Sources of interest need to be identified so that the results of this study can be put to use effectively. Each of the sources was chosen to be included in the seed orchard because of its potential use as Christmas tree stock. However, because the clonal material was propagated by grafting, the trees in the seed orchard do not represent the true phenotypes of the sources, and therefore should not be evaluated on appearance. To fairly evaluate the products of the seed orchard, a progeny study should be established from the open-pollinated seed of every source. This type of evaluation combined with yield information would aid in making decisions about which sources should be removed to improve the quality of the seed orchard. Due to the size of the trees in the orchard at this time, this study should be initiated relatively soon.

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[3] Rudolf, P.O, K.W. Dorman, R.G. Hitt and A.P. Plummer. 1974. Production of genetically improved seed. pp. 53-74. USDA Forest Service Agric. Handb. 450. Seeds of woody plants in the United States. U.S. Government Printing Office, Washington, D.C.

Observations during this study indicated that there is considerable variation in year-to-year yields. Further work needs to be done to determine cyclic yield patterns, and to determine if these patterns are unique by tree or by source. Also, it seems probable that weather has a considerable influence on yield parameters. Information should be collected on the possibility of a relationship between weather conditions at the time of cone development and cone yield, and on the possibility of a relationship between weather conditions at the time of pollination or fertilization and seed yield.

Other future studies involving seeds should include investigations of possible relationships between the time of flowering and seed size. Observations indicated that sources with later dates of ovulate cone receptivity tended to have larger seeds. Large seeds appeared to have thinner seed coats than smaller seeds, and were more susceptible to damage or destruction during handling. Research in this area should probably include data on seed coat structure as well as thickness, and the effect these dimensions have on germination rate and seedling survival for each source.

Another area deserving study is the variability in pollen viability. The data collected have indicated that viability may vary with how long the cones have been dehiscient at the time of collection, or with how late dehiscience began. This information is extremely important because it will influence the prediction of what crosses are probable. Knowledge of the dispersion patterns of pollen would also be helpful in determining which

crosses are probable. Isozyme analysis of endosperm and embryo tissues would be helpful in this area, but much work would first be required to identify suitable marker alleles.

Variability among sources in the seed orchard is probably due to a combination of several factors. The fact that the trees are from different geographic areas has been assumed to be a major cause of variation, but the importance of this fact has not been assessed. Each of the yield and phenology characteristics investigated needs to be correlated with the latitude, longitude and elevation of the sources to determine the importance of geographic origin. Information obtained from a study such as this would be useful for collecting desirable germplasm for future seed orchards.

The results of this study have made it possible to evaluate the 42 sources in the seed orchard on several characteristics. Future studies on Scotch pine trees in Nebraska can emphasize many different areas based on this information on cone production, seed yield and flowering phenology in this seed orchard.

7. Information Disclosure

Presentations:

Boes, T.K., J.R. Brandle and W.R Lovett. Flowering phenology in a Scotch pine seed orchard as a possible cause of low seed yield. The Nebraska Academy of Sciences, Lincoln, NE, 1986.

Presentations in Preparation:

Boes, T.K., J.R. Brandle and W.R. Lovett. Seed production potential of Scotch pine trees evaluated in a clonal seed orchard in Nebraska. 10th Annual Trees For Nebraska Conference, Lincoln, NE, 1987.

Publications in Preparation:

Boes, T.K. The use of $GA_{4/7}$ to promote flowering in Scotch pine (Pinus sylvestris L.). PhD. Dissertation, University of Nebraska, Lincoln.

Boes, T.K., J.R. Brandle and W.R. Lovett. Evaluation of source variability on flowering phenology, cone production and seed production in a Scotch pine (Pinus sylvestris L.) seed orchard.

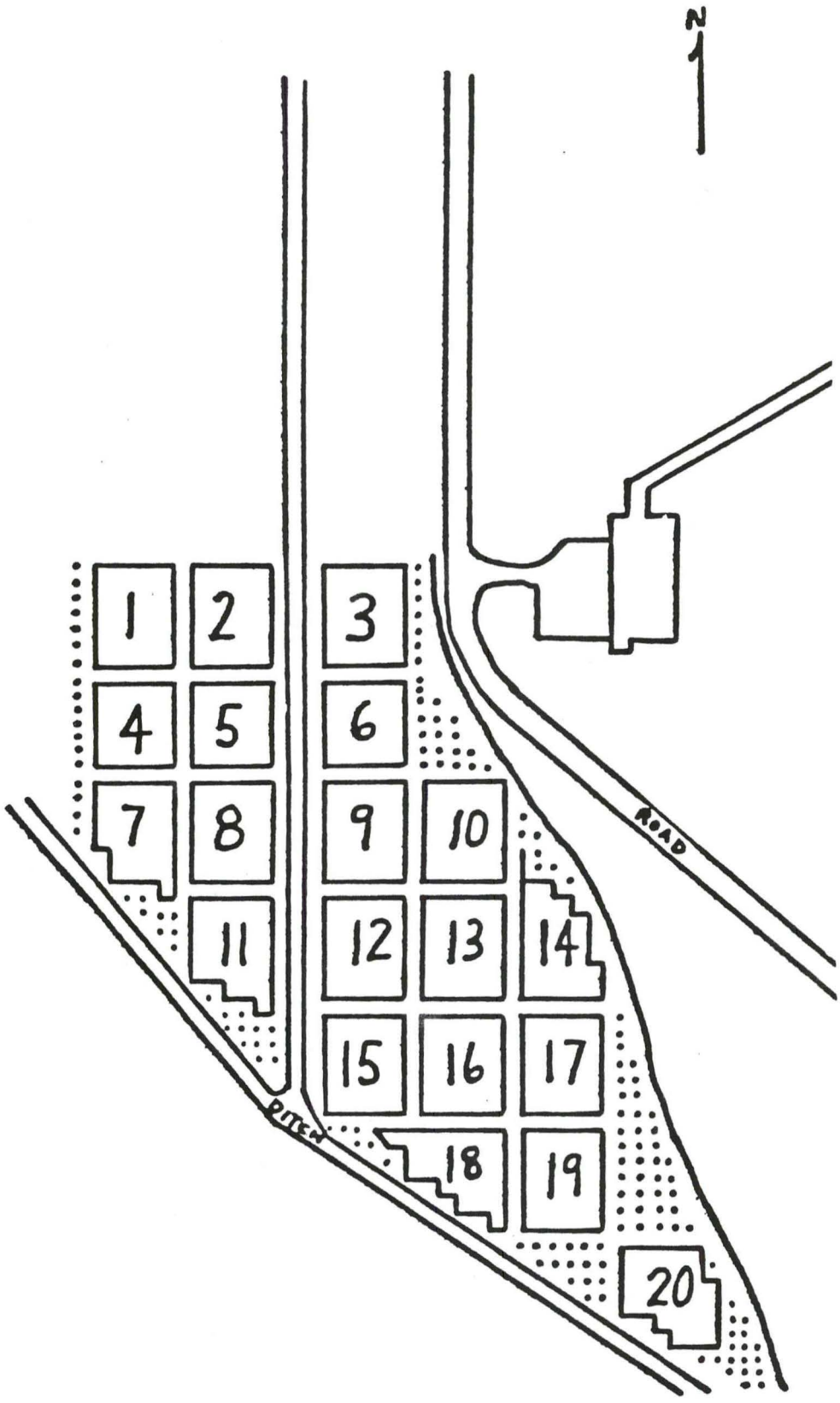

Figure 1. SCOTCH PINE CLONAL SEED ORCHARD AT THE UNIVERSITY OF NEBRASKA AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER.

Figure 2. BEGINNING AND ENDING DATES OF STAMINATE CONE DEHISCIENCE. Values are an average of two years of data. Average beginning date = Julian Day 123, and average ending date = Julian Day 134.

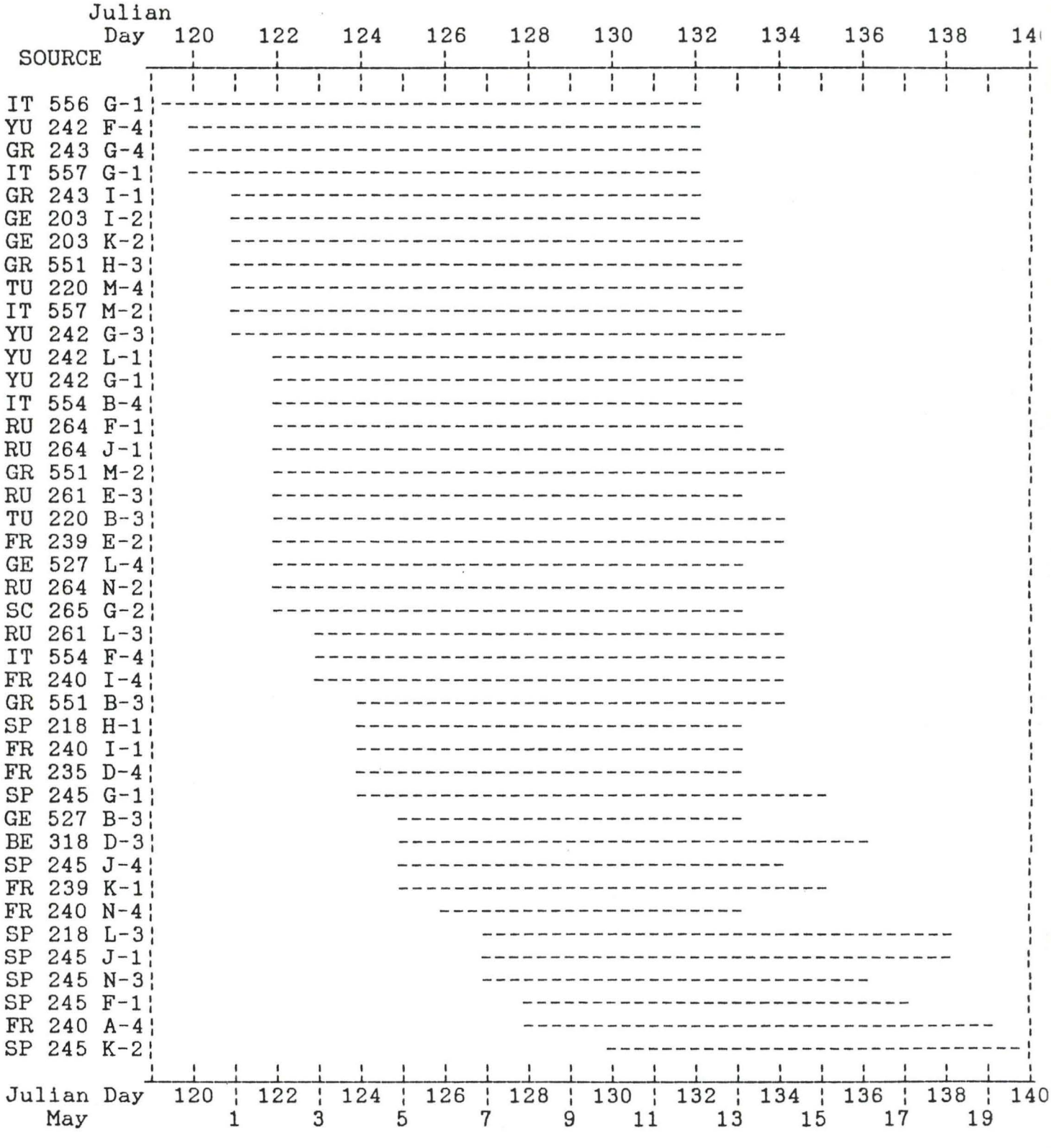

Figure 3. BEGINNING AND ENDING DATES OF OVULATE CONE RECEPTIVITY. Values are an average of two years of data. Average beginning date = Julian Day 124, and average ending date = Julian Day 130.

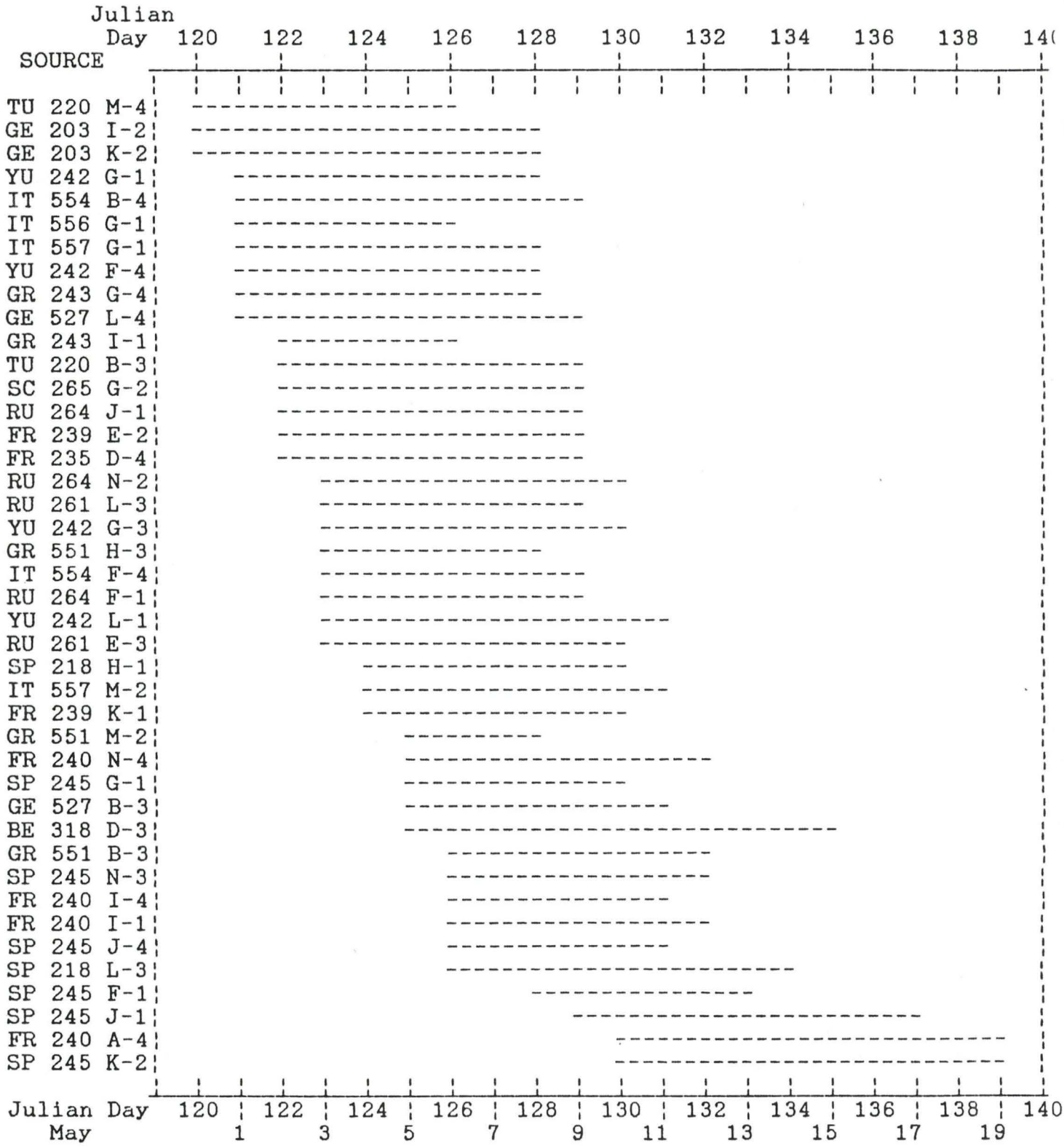

Table 1. NUMBER OF CONES PRODUCED PER SQUARE METER OF CANOPY SURFACE AREA. Mean values are an average of 3 years of data. Average mean value = 7.02 cones.

RANK	SOURCE	N	MEAN (# cones)	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN
1	IT 554 B-4	14	21.33	13.54	2.30	39.03	3.62
2	FR 240 N-4	8	18.28	16.97	3.55	53.17	6.00
3	GR 243 G-4	15	17.85	11.91	4.94	42.45	3.08
4	FR 239 E-2	14	15.11	10.59	2.27	36.30	2.83
5	GE 527 L-4	14	14.60	3.11	9.30	19.12	0.83
6	FR 240 I-4	18	13.87	4.97	7.43	25.67	1.17
7	FR 240 I-1	14	12.58	4.76	5.40	22.25	1.27
8	FR 235 D-4	14	11.03	6.60	1.55	19.47	1.76
9	RU 261 L-3	14	10.96	11.98	0.18	32.21	3.20
10	TU 220 B-3	13	10.31	7.86	0.87	22.16	2.18
11	IT 557 G-1	15	10.11	8.73	0.81	30.73	2.25
12	SP 218 L-3	14	9.49	7.04	1.13	22.07	1.88
13	YU 242 L-3	14	9.24	6.27	1.82	23.20	1.67
14	RU 261 E-3	14	8.11	7.61	0.60	21.14	2.03
15	IT 557 M-2	14	7.97	7.29	0.05	23.99	1.95
16	GE 527 B-3	14	7.77	5.50	0.92	17.25	1.47
17	SP 245 G-1	14	6.82	4.97	1.18	15.94	1.33
18	YU 242 G-1	12	6.52	3.56	2.73	16.82	1.03
19	SC 265 G-2	16	6.20	3.22	2.76	13.37	0.81
20	BE 318 D-3	14	5.76	4.16	1.01	14.37	1.11
21	IT 556 G-1	14	5.61	4.17	0.14	12.64	1.12
22	GE 203 I-2	14	5.58	2.50	2.29	8.85	0.67
23	TU 220 M-4	14	5.15	4.10	0.39	13.93	1.10
24	GE 203 K-2	14	4.99	4.22	1.32	12.36	1.13
25	RU 264 N-2	14	4.67	6.69	0.23	20.81	1.79
26	YU 424 G-3	13	4.53	3.27	1.26	11.95	0.91
27	IT 554 F-4	11	3.41	3.63	0.38	9.79	1.10
28	RU 264 F-1	14	3.08	2.55	0.33	9.51	0.68
29	SP 245 J-1	14	3.02	1.55	0.83	5.61	0.41
30	SP 245 K-2	15	2.93	1.93	0.85	8.58	0.50
31	FR 240 A-4	14	2.59	1.27	1.28	5.65	0.34
32	SP 245 J-4	13	2.51	3.84	0.03	10.70	1.07
33	GR 243 I-1	15	2.33	1.17	0.34	4.03	0.30
34	SP 245 N-3	14	2.16	2.62	0.07	8.76	0.70
35	GR 551 H-3	15	2.03	2.72	0.01	10.11	0.70
36	SP 245 F-1	14	1.67	1.06	0.31	3.95	0.28
37	SP 218 H-1	12	1.33	2.58	0.03	8.53	0.74
38	RU 264 J-1	14	1.32	0.92	0.45	3.33	0.25
39	FR 239 K-1	14	1.27	1.64	0.08	6.50	0.44
40	GR 551 B-3	13	1.22	0.90	0.01	2.64	0.25
41	YU 242 F-4	7	1.10	0.65	0.16	2.10	0.25
42	GR 551 M-2	2	0.02	0.00	0.02	0.02	0.00

Table 2. TOTAL NUMBER OF CONES PRODUCED PER TREE. Mean values are an average of 3 years of data. Average mean value = 409.66 cones.

RANK	SOURCE	N	MEAN (# cones)	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN
1	IT 554 B-4	14	1318.43	806.01	151.00	2558.00	215.42
2	GE 527 L-4	14	1159.29	178.84	850.00	1416.00	47.80
3	GR 243 G-4	15	1037.93	663.89	285.00	2713.00	171.42
4	FR 240 I-4	20	890.50	384.76	279.00	1720.00	86.03
5	FR 239 E-2	15	851.73	521.55	168.00	2035.00	134.66
6	FR 235 D-4	15	671.33	342.73	74.00	1195.00	88.49
7	RU 261 L-3	14	660.71	736.89	17.00	1942.00	196.94
8	FR 240 N-4	23	654.17	720.21	8.00	3206.00	150.17
9	TU 220 B-3	13	636.46	434.28	48.00	1328.00	120.45
10	IT 557 G-1	15	634.53	487.55	53.00	1740.00	125.88
11	YU 242 L-3	14	627.57	446.49	110.00	1646.00	119.33
12	RU 261 E-3	14	596.71	513.26	51.00	1540.00	137.17
13	FR 240 I-1	15	533.33	167.54	265.00	796.00	43.26
14	SP 218 L-3	15	531.53	392.33	41.00	1309.00	101.30
15	BE 318 D-3	14	477.64	371.93	68.00	1323.00	99.40
16	GE 527 B-3	14	460.50	374.72	47.00	1297.00	100.15
17	IT 556 G-1	14	453.93	348.57	12.00	1048.00	93.16
18	IT 557 M-2	14	452.36	423.73	3.00	1476.00	113.25
19	TU 220 M-4	14	431.14	316.67	27.00	965.00	84.63
20	GE 203 K-2	14	426.86	404.56	84.00	1118.00	108.12
21	YU 242 G-1	12	400.17	163.50	184.00	745.00	47.20
22	RU 264 N-2	14	363.29	478.96	18.00	1442.00	128.01
23	SC 265 G-2	16	351.19	145.30	172.00	675.00	36.32
24	YU 242 G-3	13	349.38	220.77	97.00	811.00	61.23
25	SP 245 G-1	28	313.00	246.30	4.00	984.00	46.55
26	GE 203 I-2	34	278.97	146.46	57.00	594.00	25.12
27	SP 245 J-1	29	255.31	112.74	63.00	494.00	20.94
28	RU 264 F-1	14	210.93	132.58	28.00	499.00	35.43
29	FR 240 A-4	29	192.48	91.06	48.00	392.00	16.91
30	IT 554 F-4	11	191.36	228.75	13.00	712.00	68.97
31	SP 245 J-4	14	170.43	265.64	3.00	752.00	70.99
32	GR 243 I-1	15	170.00	105.69	19.00	354.00	27.29
33	GR 551 H-3	15	161.73	200.96	1.00	767.00	51.89
34	SP 245 N-3	15	132.20	130.77	7.00	455.00	33.76
35	SP 245 K-2	29	130.66	99.61	17.00	448.00	18.50
36	SP 245 F-1	16	117.94	72.50	20.00	267.00	18.12
37	GR 551 B-3	13	103.92	84.59	1.00	238.00	23.46
38	SP 218 H-1	13	98.85	167.67	2.00	523.00	46.50
39	FR 239 K-1	15	97.47	135.49	5.00	525.00	34.98
40	RU 264 J-1	35	79.60	56.57	3.00	296.00	9.56
41	YU 242 F-4	7	66.00	34.10	8.00	106.00	12.89
42	GR 551 M-2	3	2.00	1.00	1.00	3.00	0.58

Table 3. SEED WEIGHT PER CONE. Mean values are an average of 3 years of data. Average mean value = 92.51 mg.

RANK	SOURCE	N	MEAN (mg)	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN
1	GE 203 I-2	35	198.76	83.04	31.21	332.00	14.04
2	TU 220 M-4	14	128.93	109.44	13.30	282.00	29.25
3	RU 264 J-1	35	182.87	81.73	21.25	341.17	13.82
4	RU 264 F-1	14	169.40	125.08	14.40	384.00	33.43
5	RU 264 N-2	14	161.42	87.93	35.70	282.00	23.50
6	YU 242 F-4	7	150.56	137.63	16.10	337.37	52.02
7	SC 265 G-2	14	145.24	100.77	28.10	306.00	26.93
8	SP 245 N-3	15	128.69	125.71	11.70	385.71	32.46
9	TU 220 B-3	13	127.33	107.33	22.10	320.00	29.77
10	FR 239 E-2	15	123.49	92.00	13.88	270.00	23.75
11	GE 527 L-4	15	114.92	70.39	23.73	224.00	18.18
12	IT 557 G-1	15	112.06	85.10	14.39	226.00	21.97
13	FR 235 D-4	15	109.41	66.31	21.74	206.00	17.12
14	SP 245 J-4	13	105.72	113.55	1.98	279.16	31.49
15	RU 261 L-3	15	105.27	86.33	21.10	294.28	22.29
16	RU 261 E-3	14	104.10	66.06	20.00	208.00	17.65
17	GE 203 K-2	14	99.74	74.70	11.93	199.00	19.96
18	YU 242 L-1	14	97.52	61.42	12.50	175.00	16.41
19	IT 554 B-4	14	93.18	56.56	12.93	167.00	15.12
20	BE 318 D-3	14	93.06	67.79	15.88	183.00	18.12
21	GE 527 B-3	14	92.48	77.42	9.60	231.42	20.69
22	FR 240 I-4	18	91.79	60.51	15.00	193.00	14.26
23	GR 243 G-4	14	90.22	70.48	19.10	192.00	18.84
24	GR 551 B-3	12	83.48	52.84	6.27	143.00	15.25
25	SP 245 F-1	15	81.78	103.43	4.90	268.00	26.71
26	SP 218 H-1	14	77.96	85.08	6.80	212.50	22.74
27	SP 245 G-1	29	76.39	89.65	6.36	294.73	16.65
28	GR 551 M-2	2	75.00	35.36	50.00	100.00	25.00
29	IT 554 F-4	11	73.15	71.36	10.80	225.00	21.52
30	FR 239 K-1	15	70.61	63.30	5.79	183.33	16.35
31	SP 218 L-3	15	62.56	79.39	5.70	224.00	20.50
32	IT 556 G-1	13	67.72	54.38	10.90	168.00	15.08
33	GR 243 I-1	15	63.54	44.76	9.41	128.00	11.56
34	YU 242 G-3	14	57.75	52.77	11.14	149.00	14.11
35	YU 242 G-1	12	56.11	50.57	5.07	136.00	14.60
36	GR 551 H-3	16	55.54	63.92	4.60	255.00	15.98
37	FR 240 I-1	15	41.59	42.94	6.00	108.00	11.09
38	FR 240 N-4	23	36.58	42.40	0.60	147.50	8.84
39	SP 245 J-1	29	31.22	36.87	4.30	141.00	6.85
40	IT 557 M-2	14	25.23	54.32	1.20	213.00	14.52
41	SP 245 K-2	29	19.07	31.58	0.77	106.00	5.86
42	FR 240 A-4	29	7.98	5.68	1.20	23.00	1.06

Table 4. SEED WEIGHT PER TREE. Mean values are an average of 3 years of data. Average mean value = 32.71 g.

RANK	SOURCE	N	MEAN (g)	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN
1	GE 527 L-4	15	126.20	90.19	30.02	294.56	23.29
2	IT 554 B-4	14	94.28	70.17	20.20	210.54	18.75
3	FR 240 I-4	18	80.05	60.71	11.64	233.92	14.31
4	GR 243 G-4	14	78.52	61.87	16.45	186.43	16.54
5	FR 239 E-2	15	67.55	38.31	19.28	127.00	9.89
6	GE 203 K-2	14	67.22	85.48	1.35	198.70	22.84
7	BE 318 D-3	14	60.68	69.79	1.08	211.68	18.65
8	FR 235 D-4	15	57.73	33.65	8.70	111.68	8.69
9	TU 220 M-4	14	57.51	62.47	1.21	219.70	16.69
10	IT 557 G-1	15	57.19	60.20	2.19	189.14	15.54
11	YU 242 L-1	14	54.32	50.04	4.94	172.37	13.37
12	TU 220 B-3	13	53.45	40.32	7.00	120.98	11.18
13	GE 203 I-2	35	51.25	35.08	3.09	154.84	5.93
14	SC 265 G-2	14	50.55	40.32	8.86	129.19	10.78
15	IT 556 G-1	13	38.25	56.14	0.48	176.06	15.57
16	RU 261 E-3	14	36.68	19.01	9.05	65.74	5.08
17	GE 527 B-3	14	34.73	41.23	1.94	157.71	11.02
18	RU 264 N-2	14	28.38	21.08	2.79	64.54	5.63
19	RU 261 L-3	14	26.70	19.00	2.91	56.51	5.08
20	RU 264 F-1	14	26.24	21.54	6.18	82.94	5.76
21	SP 218 L-3	15	25.30	31.70	0.33	103.26	8.18
22	YU 242 G-1	12	24.59	25.58	1.53	74.81	7.38
23	IT 554 F-4	11	24.07	35.71	0.21	96.12	10.77
24	FR 240 I-1	15	23.50	27.71	3.20	82.62	7.15
25	SP 245 G-1	29	22.30	42.17	0.07	205.94	7.83
25	FR 240 N-4	23	21.17	34.74	0.14	147.63	7.24
27	YU 242 G-3	13	20.69	26.13	2.69	90.44	7.25
28	IT 557 M-2	14	15.75	45.33	0.03	172.53	12.11
29	SP 245 F-1	15	12.53	19.56	0.57	54.03	5.05
30	RU 264 J-1	35	12.41	8.52	0.80	41.30	1.44
31	GR 243 I-1	15	12.38	13.95	0.77	45.31	3.60
32	YU 242 F-4	7	10.79	12.91	0.42	33.74	4.88
33	FR 239 K-1	15	9.85	18.30	0.11	69.30	4.72
34	GR 551 H-3	16	8.79	12.81	0.00	47.69	3.20
35	GR 551 B-3	12	8.78	10.88	0.14	32.75	3.14
36	SP 245 N-3	15	8.29	11.73	0.86	48.48	3.03
37	SP 245 J-1	29	7.18	8.83	0.47	37.26	1.64
38	SP 254 J-4	13	2.92	2.43	0.21	7.22	0.67
39	SP 218 H-1	14	2.85	1.91	0.12	6.80	0.51
40	SP 245 K-2	29	2.83	4.95	0.05	17.03	0.92
41	FR 240 A-4	29	1.55	1.36	0.25	4.82	0.25
42	GR 551 M-2	2	0.10	0.00	0.10	0.10	0.00

Table 5. AVERAGE WEIGHT OF 1000 SEEDS. Mean values are an average of 2 years of data. Average mean value = 10.86 g.

RANK	SOURCE	N	MEAN (g)	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN
1	SP 245 J-4	9	18.14	2.86	13.13	21.10	0.95
2	RU 264 J-1	31	15.77	0.63	14.80	17.10	0.11
3	SP 218 L-3	11	14.24	1.79	11.70	16.60	0.54
4	RU 261 E-3	10	13.99	0.88	12.58	15.50	0.28
5	SP 245 N-3	11	13.81	3.06	8.38	17.00	0.92
6	SP 218 H-1	10	13.79	1.58	12.00	15.70	0.50
7	SP 245 J-1	25	13.62	1.18	11.89	16.90	0.24
8	SP 245 K-2	24	12.62	1.75	10.00	16.20	0.36
9	RU 264 F-1	10	12.54	0.55	11.48	13.30	0.17
10	RU 264 N-2	10	12.44	0.38	11.63	13.08	0.12
11	FR 240 A-4	25	12.35	1.05	10.00	15.36	0.21
12	YU 242 G-3	10	12.00	1.00	10.65	13.70	0.32
13	TU 220 B-3	9	11.76	1.04	10.40	13.30	0.35
14	SP 245 F-1	11	11.51	0.99	10.00	12.64	0.30
15	FR 240 I-1	11	11.29	1.29	9.82	13.10	0.39
16	RU 261 L-3	10	10.81	0.36	10.10	11.20	0.11
17	YU 242 L-1	10	10.53	0.51	9.71	11.50	0.16
18	YU 242 F-4	5	10.45	0.43	9.73	10.77	0.19
19	SP 245 G-1	25	10.52	1.02	7.78	12.40	0.20
20	FR 240 N-4	21	10.39	0.78	7.78	12.00	0.17
21	YU 242 G-1	8	10.24	0.60	9.70	11.40	0.21
22	IT 557 M-2	10	9.78	1.24	7.50	12.00	0.39
23	IT 557 G-1	10	9.75	0.27	9.23	10.20	0.09
24	GE 527 B-3	10	9.48	0.79	8.14	10.80	0.25
25	SC 265 G-2	10	9.40	0.40	8.66	10.00	0.13
26	TU 220 M-4	10	9.38	0.61	7.86	10.20	0.19
27	FR 240 I-4	14	9.13	0.40	8.47	9.90	0.11
28	BE 318 D-3	10	9.15	0.46	8.38	9.70	0.14
29	GE 203 I-2	31	8.96	0.52	8.00	10.07	0.09
30	GR 243 I-1	10	8.77	0.23	8.40	9.12	0.07
31	GR 551 B-3	8	8.47	0.41	7.78	8.90	0.15
32	FR 239 E-2	11	8.34	0.63	7.34	9.10	0.19
33	FR 239 K-1	11	8.02	0.50	7.08	8.90	0.15
34	IT 556 G-1	9	7.96	0.48	7.22	8.89	0.16
35	IT 554 F-4	8	7.95	0.81	6.69	9.20	0.29
36	GE 527 L-4	11	7.93	0.38	7.39	8.60	0.11
37	GR 243 G-4	9	7.80	0.33	7.28	8.30	0.11
38	FR 235 D-4	11	7.64	0.38	6.93	8.20	0.11
39	IT 554 B-4	10	7.46	0.89	6.44	8.70	0.28
40	GR 551 H-3	12	7.23	1.28	4.60	10.00	0.37
41	GE 203 K-2	10	7.00	0.88	6.50	9.45	0.28
42	GR 551 M-2	2	6.60	0.00	6.60	6.60	0.00

Table 6. NUMBER OF SEEDS PRODUCED PER CONE. Mean values are an average of 2 years of data. Average mean value = 11.21 seeds.

RANK	SOURCE	N	MEAN (# seeds)	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN
1	GE 203 I-2	31	24.66	7.70	8.35	38.07	1.38
2	SC 265 G-2	10	20.04	8.14	9.68	31.55	2.57
3	YU 242 F-4	5	19.44	11.95	4.87	31.82	5.34
4	GE 203 K-2	10	19.28	9.24	4.50	28.84	2.92
5	FR 239 E-2	11	18.99	7.84	5.22	30.34	2.36
6	GE 527 L-4	11	18.06	6.64	6.25	26.38	2.00
7	FR 235 D-4	11	17.98	5.79	8.87	25.51	1.74
8	TU 220 M-4	10	17.93	10.09	3.85	27.65	3.19
9	RU 264 F-1	10	17.73	7.51	9.33	30.00	2.38
10	RU 264 N-2	10	16.75	4.20	8.04	22.38	1.33
11	GR 243 G-4	9	16.30	7.08	5.65	23.70	2.36
12	IT 554 B-4	10	16.10	3.31	9.75	20.12	1.05
13	IT 557 G-1	10	16.09	6.48	4.45	22.83	2.05
14	TU 220 B-3	9	14.19	6.93	4.73	24.06	2.31
15	RU 264 J-1	31	14.13	7.91	4.38	47.55	1.42
16	GR 551 B-3	8	13.93	2.79	10.40	18.00	0.99
17	RU 261 L-3	10	13.35	7.07	3.74	26.27	2.23
18	BE 318 D-3	10	13.08	5.91	2.19	19.06	1.87
19	FR 240 I-4	14	12.27	5.86	4.97	22.18	1.57
20	SP 245 N-3	11	12.26	8.98	1.72	31.33	2.71
21	YU 242 L-1	10	12.02	4.00	5.34	16.89	1.27
22	GE 527 B-3	10	11.75	7.13	3.58	21.42	2.26
23	IT 556 G-1	9	11.46	5.78	4.50	20.24	1.93
24	FR 239 K-1	11	11.37	7.64	3.16	21.66	2.30
25	IT 554 F-4	8	11.31	7.83	2.30	24.46	2.77
26	GR 551 M-2	2	10.50	4.95	7.00	14.00	3.50
27	GR 243 I-1	10	10.11	3.70	4.78	14.55	1.17
28	RU 261 E-3	10	9.57	3.73	4.36	15.52	1.18
29	GR 551 H-3	12	8.90	6.83	1.00	25.50	1.97
30	SP 245 F-1	11	8.76	8.92	0.48	21.97	2.69
31	SP 245 G-1	25	7.71	7.61	0.82	23.76	1.52
32	YU 242 G-1	8	7.66	4.31	1.84	11.93	1.52
33	SP 245 J-4	9	7.58	5.25	0.13	13.28	1.75
34	SP 218 H-1	10	6.99	5.44	1.11	13.53	1.72
35	YU 242 G-3	10	6.10	4.03	1.68	12.11	1.27
36	SP 218 L-3	11	5.14	5.21	0.47	13.49	1.57
37	FR 240 I-1	11	4.47	3.35	0.81	8.78	1.01
38	IT 557 M-2	10	3.73	7.50	0.92	25.06	2.37
39	FR 240 N-4	21	3.72	4.13	0.05	14.20	0.90
40	SP 245 J-1	25	2.41	2.43	0.33	8.70	0.49
41	SP 245 K-2	24	1.47	2.16	0.06	6.88	0.44
42	FR 240 A-4	25	0.63	0.44	0.12	1.69	0.09

Table 7. NUMBER OF SEEDS PRODUCED PER TREE. Mean values are an average of 2 years of data. Average mean value = 4202.87 seeds.

RANK	SOURCE	N	MEAN (# seeds)	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN
1	GE 527 L-4	11	19752.65	9901.08	5172.18	34255.75	2985.29
2	IT 554 B-4	10	17012.70	10971.79	2899.20	30794.00	3469.58
3	GE 203 K-2	10	13601.53	13141.50	450.00	30443.14	4155.71
4	GR 243 G-4	9	13031.54	8229.45	2197.85	23012.70	2743.15
5	FR 240 I-4	14	10421.83	6390.87	2025.54	23625.92	1708.03
6	FR 239 E-2	11	9917.40	3608.98	3265.92	14051.70	1088.15
7	FR 235 D-4	11	8991.40	4149.78	1191.40	14181.60	1251.21
8	BE 318 D-3	10	8688.48	7761.61	181.77	23258.34	2454.44
9	TU 220 M-4	10	7760.73	6885.54	153.90	23127.65	2177.40
10	IT 557 G-1	10	7528.48	6856.70	235.85	19101.84	2168.28
11	SC 265 G-2	10	6753.32	4065.75	1713.36	13181.85	1285.70
12	IT 556 G-1	9	6390.56	7762.23	54.00	21211.52	2587.41
13	YU 242 L-1	10	6285.41	4972.40	587.40	15671.35	1572.41
14	GE 203 I-2	31	6279.61	4038.04	1516.88	17599.05	725.25
15	TU 220 B-3	9	5396.18	3571.64	608.64	9451.68	1190.55
16	GE 527 B-3	10	4840.92	5134.72	273.54	18158.00	1623.74
17	IT 554 F-4	8	3864.48	4554.27	29.90	11584.24	1610.18
18	YU 242 G-1	8	3336.11	2506.19	369.84	7405.12	886.07
19	RU 261 E-3	10	2641.58	1635.39	632.20	4878.30	517.16
20	RU 264 F-1	10	2571.26	1721.18	543.76	6480.00	544.28
21	FR 240 I-1	11	2482.60	2283.46	302.10	6303.60	688.49
22	IT 557 M-2	10	2437.71	6298.26	3.99	20298.60	1991.68
23	SP 245 G-1	25	2177.07	3874.05	9.00	17598.68	774.81
24	YU 242 G-3	9	2164.14	2391.46	246.96	7350.77	797.15
25	GR 243 I-1	10	2010.01	1667.90	90.82	5150.70	527.44
26	FR 240 N-4	21	1950.07	3435.26	11.70	14058.10	749.64
27	SP 218 L-3	11	1906.13	2225.11	25.99	6218.89	670.90
28	RU 261 L-3	9	1746.17	1532.68	280.50	5056.20	510.89
29	RU 264 N-2	10	1733.02	1520.26	223.20	4980.85	480.75
30	FR 239 K-1	11	1658.96	2566.02	77.00	8662.50	773.68
31	GR 551 B-3	8	1451.71	1335.73	5.00	3764.76	472.25
32	YU 242 F-4	5	1378.84	1305.12	38.96	3182.00	583.67
33	SP 245 F-1	11	1328.33	1753.12	55.60	4288.03	528.58
34	GR 551 H-3	12	1232.93	1570.99	1.00	4768.50	453.51
35	RU 264 J-1	31	851.19	553.25	45.99	2614.50	99.37
36	SP 245 N-3	11	696.45	851.69	60.00	2992.00	256.80
37	SP 245 J-1	25	566.46	620.75	37.95	2570.25	124.15
38	SP 245 K-2	24	199.89	343.61	2.98	1052.10	70.14
39	SP 218 H-1	10	185.24	147.49	9.99	432.96	46.64
40	FR 240 A-4	25	133.69	108.03	18.97	364.48	21.61
41	SP 245 J-4	9	109.74	101.96	15.99	318.00	33.99
42	GR 551 M-2	2	14.00	0.00	14.00	14.00	0.00

Table 8. SEED GERMINATION PERCENTAGE. Mean values are an average of 1 year of data. Average mean value = 87.69 %.

RANK	SOURCE	N	MEAN (%)	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN
1	GR 551 M-2	2	100.00	0.00	100.00	100.00	0.00
2	GR 243 G-4	4	96.50	1.29	95.00	98.00	0.65
3	RU 264 N-2	5	95.80	1.30	94.00	97.00	0.58
4	YU 242 F-4	2	95.50	0.71	95.00	96.00	0.50
5	TU 220 M-4	5	94.60	1.67	92.00	96.00	0.75
6	RU 264 J-1	26	93.12	2.60	85.00	96.00	0.51
7	FR 235 D-4	5	93.00	3.74	87.00	96.00	1.67
8	TU 220 B-3	4	93.00	2.83	89.00	95.00	1.41
9	BE 318 D-3	5	92.60	1.14	91.00	94.00	0.51
9	RU 264 F-1	5	92.60	2.97	88.00	96.00	1.33
9	SC 265 G-2	5	92.60	0.89	92.00	94.00	0.40
12	FR 240 N-4	3	92.33	0.58	92.00	93.00	0.33
13	GE 203 K-2	5	91.80	1.30	90.00	93.00	0.58
14	IT 554 B-4	5	91.60	1.14	90.00	93.00	0.51
14	RU 261 E-3	5	91.60	2.19	89.00	95.00	0.98
16	GE 527 L-4	6	91.50	2.43	88.00	94.00	0.99
16	YU 242 G-1	4	91.50	1.29	90.00	93.00	0.65
18	FR 239 E-2	5	91.40	4.98	83.00	95.00	2.23
19	IT 554 F-4	4	90.75	1.50	90.00	93.00	0.75
20	SP 245 G-1	5	90.60	3.21	85.00	93.00	1.44
21	YU 242 L-1	5	90.40	1.67	88.00	92.00	0.75
22	SP 245 J-4	5	90.20	2.05	88.00	92.00	0.92
23	FR 240 I-4	6	89.33	1.51	88.00	92.00	0.61
24	FR 240 I-1	5	88.80	2.39	86.00	92.00	1.07
25	GE 527 B-3	5	88.60	5.90	80.00	94.00	2.64
26	YU 242 G-3	5	88.00	2.92	84.00	91.00	1.30
27	GR 551 H-3	6	87.83	4.36	83.00	96.00	1.78
28	SP 245 J-1	5	87.80	4.44	80.00	91.00	1.98
29	IT 557 G-1	5	87.60	1.82	86.00	90.00	0.81
30	GE 203 I-2	26	87.54	4.67	69.00	92.00	0.92
31	RU 261 L-3	5	86.60	9.74	70.00	94.00	4.35
31	SP 245 K-2	5	86.60	5.22	79.00	92.00	2.34
33	SP 218 H-1	5	86.00	2.00	83.00	88.00	0.89
34	GR 243 I-1	5	85.60	2.07	84.00	89.00	0.93
35	SP 245 N-3	5	85.40	9.26	71.00	96.00	4.14
36	IT 556 G-1	4	83.25	3.86	79.00	87.00	1.93
37	FR 239 K-1	5	80.60	3.21	78.00	85.00	1.44
38	SP 245 F-1	5	80.00	12.29	59.00	88.00	5.50
39	GR 551 B-3	5	79.00	22.42	39.00	91.00	10.02
40	IT 557 M-2	5	68.00	14.68	48.00	88.00	6.57
41	SP 218 L-3	5	65.00	16.25	38.00	78.00	7.27
42	FR 240 A-4	5	42.60	6.69	38.00	54.00	2.99

Table 9. RANKS OF ALL YIELD VARIABLES. Sources with the same value for average rank (col. 3) were assigned the same rank number (col. 1). Mean average rank = 21.50.

			RANKS							
RANK	SOURCE	AVERAGE RANK	# cones/ m2	# cones/ tree	seed wt/ cone	seed wt/ tree	wt/ 1000 seeds	# seed/ cone	# seed/ tree	% germination
1	GE 527 L-4	9.75	5	2	11	1	36	6	1	16
2	FR 239 E-2	10.63	57	4	5	10	5	32	5	6
3	GR 243 G-4	10.88	3	3	23	4	37	11	4	2
4	IT 554 B-4	11.25	1	1	19	2	39	12	2	14
5	TU 220 B-3	11.25	10	9	9	12	13	14	15	8
6	FR 235 D-4	11.75	8	6	13	8	38	7	7	7
7	TU 220 M-4	12.75	23	20	2	9	26	8	9	5
8	FR 240 I-4	13.63	6	4	22	3	27	19	5	23
9	SC 265 G-2	14.00	19	23	7	14	25	2	11	11
10	GE 203 K-2	14.50	24	21	4	6	41	4	3	13
11	IT 557 G-1	14.88	11	11	12	10	23	13	10	29
12	RU 264 N-2	15.25	25	22	5	18	10	10	29	3
13	YU 242 L-1	15.75	13	12	18	11	17	21	13	21
13	BE 318 D-3	15.75	20	16	20	7	28	18	8	9
15	RU 261 E-3	15.63	14	13	16	16	4	28	19	15
16	RU 264 F-1	16.00	28	28	4	20	9	9	20	10
17	GE 203 I-2	17.00	22	26	1	13	29	1	14	30
18	RU 261 L-3	17.75	9	7	15	19	16	17	28	31
19	GE 527 B-3	19.75	16	17	21	17	24	22	16	25
20	RU 264 J-1	21.13	38	40	3	30	2	15	35	6
21	FR 240 N-4	21.38	2	8	38	26	20	39	26	12
22	YU 242 F-4	22.13	41	41	6	32	18	3	32	4
23	FR 240 I-1	22.38	7	14	37	24	15	37	21	24
24	YU 242 G-1	23.13	18	22	35	22	21	32	18	17
25	SP 218 L-3	23.25	12	15	31	21	3	36	27	41
26	SP 245 G-1	23.38	17	25	27	25	19	31	23	20
27	IT 556 G-1	23.88	21	18	32	15	34	23	12	36
28	IT 554 F-4	25.63	27	30	29	23	35	25	17	19
29	SP 245 N-3	26.00	34	34	8	36	5	20	36	35
29	YU 242 G-3	26.00	26	24	34	27	12	35	24	26
31	SP 245 J-4	26.50	32	31	14	38	1	33	41	22
32	IT 557 M-2	28.00	15	19	40	28	22	38	22	40
33	SP 245 F-1	30.13	36	36	25	29	14	30	33	38
34	SP 245 J-1	30.50	29	27	39	37	7	40	37	28
35	GR 243 I-1	30.63	33	32	33	31	30	27	25	34
36	SP 218 H-1	31.50	37	38	26	39	6	34	39	33
37	GR 551 B-3	31.63	40	37	24	35	31	16	31	39
38	FR 239 K-1	33.13	39	39	30	33	33	24	30	37
38	SP 245 K-2	33.13	30	35	41	40	8	41	38	32
40	GR 551 M-2	33.13	42	42	28	42	42	26	42	1
41	GR 551 H-3	33.50	35	33	36	34	40	29	34	27
42	FR 240 A-4	34.75	31	29	42	41	11	42	40	42

Table 10. NUMBER OF DAYS OF STAMINATE CONE DEHISCIENCE. Sources with the same mean value (col. 3) were assigned the same rank (col. 1). Mean values are an average of two years of data. Average mean value = 10.94 days.

RANK	SOURCE	N	MEAN (days)	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN
1	IT 556 G-1	39	12.92	1.40	9.00	16.00	0.22
2	TU 220 M-4	42	12.60	1.81	6.00	16.00	0.28
3	GR 551 H-3	50	12.58	1.82	9.00	16.00	0.26
4	YU 242 G-3	38	12.42	1.97	8.00	16.00	0.32
5	IT 557 G-1	42	12.31	1.52	9.00	16.00	0.23
6	IT 557 M-2	40	12.28	2.33	2.00	16.00	0.37
7	GR 243 G-4	42	11.93	1.42	9.00	16.00	0.22
8	GE 203 K-2	40	11.80	2.45	2.00	16.00	0.39
9	YU 242 F-4	16	11.81	1.42	10.00	16.00	0.36
10	RU 264 J-1	40	11.70	2.21	6.00	16.00	0.35
11	GR 551 M-2	38	11.68	1.96	8.00	14.00	0.32
12	TU 220 B-3	39	11.64	2.11	6.00	16.00	0.34
13	GR 243 I-1	34	11.59	1.69	7.00	16.00	0.29
14	YU 242 L-1	40	11.53	1.87	8.00	16.00	0.30
15	GE 203 I-2	41	11.46	1.55	7.00	14.00	0.24
16	RU 264 F-1	34	11.44	2.00	6.00	16.00	0.34
17	RU 261 L-3	48	11.35	2.36	6.00	16.00	0.34
18	RU 261 E-3	42	11.24	1.97	6.00	14.00	0.30
19	RU 264 N-2	40	11.23	2.03	6.00	14.00	0.32
19	SP 218 L-3	40	11.23	2.33	7.00	16.00	0.37
21	FR 239 E-2	40	11.18	2.05	6.00	14.00	0.32
22	FR 240 I-4	46	11.13	2.66	6.00	16.00	0.39
23	BE 318 D-3	40	11.05	2.80	6.00	18.00	0.44
24	IT 554 B-4	38	10.97	2.04	4.00	14.00	0.33
25	IT 554 F-4	34	10.82	2.47	6.00	16.00	0.42
25	YU 242 G-1	38	10.82	1.71	7.00	14.00	0.28
27	FR 240 A-4	39	10.69	1.92	6.00	15.00	0.31
28	GE 527 L-4	42	10.67	1.84	6.00	16.00	0.28
29	SP 245 J-1	40	10.60	2.11	6.00	15.00	0.33
30	SP 245 G-1	40	10.58	2.33	6.00	16.00	0.37
31	GR 551 B-3	40	10.40	2.60	6.00	16.00	0.41
32	SC 265 G-2	39	10.36	1.98	6.00	14.00	0.32
33	SP 245 K-2	38	10.13	1.46	6.00	13.00	0.24
34	SP 218 H-1	38	9.79	2.15	6.00	14.00	0.35
35	FR 240 I-1	29	9.69	2.79	2.00	16.00	0.52
36	SP 245 F-1	40	9.53	2.75	4.00	16.00	0.44
37	SP 245 J-4	42	9.24	3.04	6.00	16.00	0.47
38	FR 239 K-1	40	9.23	2.43	2.00	12.00	0.38
39	SP 245 N-3	37	8.92	2.48	2.00	16.00	0.41
40	FR 235 D-4	33	8.61	2.15	4.00	14.00	0.37
41	GE 527 B-3	33	8.18	1.98	4.00	14.00	0.34
42	FR 240 N-4	25	7.44	2.04	4.00	12.00	0.41

Table 11. RELATIVE AMOUNT OF POLLEN PRODUCED. Values were scaled from 1 (no pollen) to 5 (excessive pollen). Sources with the same mean value (col. 3) were assigned the same rank (col. 1). Mean values are an average of two years of data. Average mean value = 3.14.

RANK	SOURCE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN
1	IT 557 M-2	40	4.73	0.51	3.00	5.00	0.08
2	FR 240 I-4	46	4.61	0.88	1.00	5.00	0.13
3	FR 239 E-2	39	4.49	0.72	2.00	5.00	0.12
4	IT 556 G-1	39	4.36	0.74	3.00	5.00	0.12
5	IT 554 F-4	34	4.15	1.10	1.00	5.00	0.19
6	IT 557 G-1	42	4.12	0.80	3.00	5.00	0.12
7	GR 243 I-1	34	4.00	0.60	3.00	5.00	0.10
8	GR 551 H-3	50	3.98	0.80	1.00	5.00	0.11
9	YU 242 L-1	40	3.83	0.50	2.00	5.00	0.08
10	RU 264 F-1	34	3.82	0.52	3.00	5.00	0.09
11	YU 242 G-3	38	3.77	0.71	2.00	5.00	0.12
12	FR 239 K-1	40	3.73	1.06	1.00	5.00	0.17
13	TU 220 M-4	42	3.43	0.67	2.00	5.00	0.10
14	RU 264 J-1	40	3.40	0.55	2.00	4.00	0.09
15	GR 551 B-3	40	3.23	0.58	2.00	4.00	0.09
16	GE 203 K-2	40	3.20	0.72	2.00	4.00	0.11
17	RU 261 E-3	42	3.17	0.66	1.00	5.00	0.10
18	RU 264 N-2	40	3.13	0.52	2.00	4.00	0.08
18	SP 245 G-1	40	3.13	0.88	2.00	5.00	0.14
20	TU 220 B-3	39	3.10	0.50	2.00	4.00	0.08
21	YU 242 G-1	38	3.03	0.75	2.00	5.00	0.12
22	SP 218 L-3	40	3.00	0.96	1.00	5.00	0.15
23	SP 245 J-4	42	2.98	1.05	1.00	5.00	0.16
24	GE 203 I-2	41	2.93	0.72	2.00	5.00	0.11
25	GE 527 L-4	42	2.90	0.58	1.00	4.00	0.09
26	SP 245 N-3	38	2.89	0.76	1.00	4.00	0.12
27	GR 243 G-4	42	2.88	1.04	1.00	5.00	0.16
27	YU 242 F-4	16	2.88	0.62	2.00	4.00	0.15
29	SP 218 H-1	38	2.82	0.93	1.00	5.00	0.15
30	BE 318 D-3	40	2.80	0.46	2.00	4.00	0.07
31	RU 261 L-3	48	2.75	0.67	1.00	4.00	0.10
32	GE 527 B-3	35	2.57	0.78	1.00	4.00	0.13
33	FR 240 A-4	40	2.53	0.64	1.00	4.00	0.10
34	SP 245 F-1	40	2.53	0.85	1.00	4.00	0.13
35	SP 245 J-1	40	2.50	0.68	1.00	4.00	0.11
36	GR 551 M-2	38	2.42	0.76	1.00	4.00	0.12
37	SC 265 G-2	40	2.40	0.74	1.00	4.00	0.12
38	IT 554 B-4	38	2.32	0.87	1.00	4.00	0.14
39	FR 235 D-4	34	2.32	0.77	1.00	4.00	0.13
40	SP 245 K-2	38	1.71	0.70	1.00	4.00	0.11
41	FR 240 N-4	36	1.33	0.89	1.00	5.00	0.15
41	FR 240 I-1	40	1.33	0.57	1.00	3.00	0.09

Table 12. POLLEN VIABILITY. Sources with the same germination value (col. 3) were assigned the same rank (col. 1). Values are are an average of three observations during one year. Average value = 54%.

RANK	SOURCE	POLLEN GERMINATION (%)
1	SP 245 J-1	91
2	RU 261 L-3	87
3	GE 527 B-3	79
3	YU 242 G-3	79
5	SP 245 G-1	78
5	TU 220 B-3	78
7	SC 265 G-2	77
8	FR 239 K-1	76
8	GE 527 L-4	76
8	SP 245 F-1	76
8	SP 218 L-3	76
12	FR 240 I-1	74
13	FR 235 D-4	73
13	FR 240 A-4	73
15	YU 242 G-1	72
16	SP 218 H-1	70
17	GE 203 K-2	68
17	SP 245 K-2	68
19	TU 220 M-4	67
20	BE 318 D-3	66
21	RU 261 E-3	65
22	RU 264 N-2	63
23	YU 242 L-1	58
24	FR 240 I-4	57
25	RU 264 F-1	52
26	GR 551 H-3	49
27	YU 242 F-4	47
28	GR 551 M-2	46
28	IT 554 B-4	46
30	FR 239 E-2	42
31	IT 557 G-1	37
32	SP 245 N-3	37
33	GE 203 I-2	27
34	IT 554 F-4	26
35	SP 245 J-4	24
36	GR 243 I-1	23
37	FR 240 N-4	19
38	GR 551 B-3	14
39	IT 556 G-1	13
40	IT 557 M-2	10
41	RU 264 J-1	8
42	GR 243 G-4	5

Table 13. NUMBER OF DAYS OF OVULATE CONE RECEPTIVITY. Sources with the same mean value (col. 3) were assigned the same rank (col. 1). Mean values are an average of two years of data. Average mean value = 6.80 days.

RANK	SOURCE	N	MEAN (days)	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN
1	BE 318 D-3	40	9.90	2.89	4.00	15.00	0.46
2	SP 245 K-2	38	9.45	2.25	2.00	13.00	0.37
3	FR 240 A-4	40	8.85	1.72	4.00	11.00	0.27
4	SP 245 J-1	40	8.80	2.28	5.00	15.00	0.36
5	IT 554 B-4	38	8.39	1.28	6.00	12.00	0.21
6	GE 527 L-4	42	8.02	2.10	4.00	12.00	0.32
7	YU 242 L-1	40	7.78	2.13	4.00	12.00	0.34
8	SP 218 L-3	40	7.73	2.97	4.00	16.00	0.47
9	TU 220 B-3	39	7.67	1.47	4.00	11.00	0.24
10	GE 203 K-2	40	7.65	1.49	4.00	12.00	0.24
11	YU 242 G-3	38	7.53	2.88	2.00	13.00	0.47
11	YU 242 G-1	40	7.53	2.29	2.00	11.00	0.37
11	RU 264 J-1	40	7.53	1.80	4.00	11.00	0.28
14	GE 203 I-2	41	7.44	1.55	4.00	10.00	0.24
15	RU 264 N-2	40	7.38	2.02	4.00	11.00	0.31
16	FR 240 N-4	36	7.28	1.99	4.00	12.00	0.33
17	FR 235 D-4	34	7.06	1.56	4.00	12.00	0.27
18	SC 265 G-2	40	7.05	1.28	4.00	11.00	0.20
19	YU 242 F-4	16	6.88	1.78	4.00	10.00	0.45
19	IT 557 M-2	40	6.88	2.15	4.00	12.00	0.34
21	GR 243 G-4	42	6.76	1.79	2.00	11.00	0.28
22	GR 551 B-3	40	6.70	2.40	2.00	11.00	0.38
23	FR 239 E-2	40	6.68	1.85	4.00	12.00	0.29
24	IT 557 G-1	42	6.55	1.82	2.00	9.00	0.28
25	RU 261 L-3	48	6.44	1.89	2.00	11.00	0.27
26	RU 261 E-3	42	6.33	1.72	4.00	10.00	0.27
27	FR 240 I-1	40	6.30	2.16	2.00	12.00	0.34
28	SP 218 H-1	38	6.29	1.90	4.00	10.00	0.31
29	RU 264 F-1	34	6.21	1.89	2.00	10.00	0.32
30	IT 554 F-4	34	6.03	2.65	2.00	16.00	0.45
30	SP 245 N-3	38	6.03	1.64	4.00	9.00	0.27
32	TU 220 M-4	42	5.95	1.59	2.00	9.00	0.25
33	GE 527 B-3	35	5.94	2.13	2.00	11.00	0.36
34	SP 245 G-1	40	5.73	1.65	4.00	9.00	0.26
35	FR 239 K-1	40	5.65	1.82	2.00	10.00	0.29
36	IT 556 G-1	39	5.44	1.93	2.00	9.00	0.31
37	SP 245 F-1	40	5.15	2.58	2.00	12.00	0.41
38	FR 240 I-4	46	5.04	1.73	2.00	10.00	0.25
39	GR 243 I-1	34	4.71	1.78	2.00	9.00	0.30
40	GR 551 H-3	49	4.65	2.10	2.00	10.00	0.30
41	SP 245 J-4	42	4.31	1.18	2.00	8.00	0.18
42	GR 551 M-2	4	4.25	2.63	2.00	8.00	1.31